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The 5E Learning Cycle: What's the Story?

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What's the Story?

Using the 5E learning cycle to create coherent storylines

By Kelsey Lipsitz, Dante Cisterna, and Deborah Hanuscin

Imagine sitting down to binge watch a TV series. Now, imagine you started with episode 4, then watched 2, then 8. Though they are all part of the same show, the story would not make much sense. Story writers employ techniques that help the audience follow the storyline as it develops—for example, a flashback would remind us of a key idea from a previous episode. Similar to story writers, teachers create sequences of instructional activities. Research shows that in many science classrooms, "ideas and activities are not woven together to tell or reveal a coherent story (Roth et al. 2011, p. 120). The 5E learning cycle (Bybee 1997) provides an important framework to help teachers organize activities.

To realize the full potential of the 5E framework for student learning, lessons must also have a coherent conceptual storyline. *Conceptual storyline* describes the conceptual flow and sequencing of science ideas within a single learning cycle lesson that helps students understand a disciplinary core idea and a scientific phenomenon (Ramsey 1993). An incoherent conceptual storyline can affect the implementation of the 5E learning cycle. Thus, the conceptual storyline should be coherent both in terms of activities and scientific concepts (McDonald, Criswell, and Dreon 2007). In this article, we elaborate on the idea of structural versus conceptual coherence in 5E lessons and describe insights from our work supporting teachers in crafting coherent conceptual storylines.

Structural Versus Conceptual Coherence

Saturday Night Live is a good example of structural coherence. Each episode begins with an opening sketch and a celebrity host monologue, which are followed by sketches and musical guests. *Saturday Night Live* follows a similar structure each episode, yet you do not need to watch every segment or watch individual episodes in any particular order to enjoy the program. This kind of teaching has been referred to as "activitymania" (Moscovici and Nelson 1998). While it may seem easy to plug activities into the structure of the 5E framework—for example, choosing a hands-on activity for the exploration phase—the activities themselves may lack conceptual coherence.

In contrast, *Stranger Things* represents conceptual coherence, in that the episodes follow the main characters (with some being introduced throughout the show) as part of an overall story. The story would not make much sense if you were watching partial episodes or episodes out of order. The sequence of the episodes is key to understanding the overall storyline. This is analogous to a sequence of activities such as a 5E learning cycle that helps students build and connect ideas to one another over time. Let's illustrate this with an example.

In our professional development program, we use a conceptual storyline probe (Figure 1) to highlight differences between two teachers' lessons about matter. We ask: What do you notice about the two lessons? How are they alike? How are they different? Teachers might consider different parts of the lessons such as opportunities for students to engage in hands-on activities, students' level of interest or enthusiasm in the activities, and whether the activities connect to students' everyday experiences. Yet, there is more to consider in terms of coherence.

The activities selected by the two teachers follow the structure of the 5E learning cycle. Both teachers begin with activities that allow them to gain insight into students' prior knowledge of the topic and build interest in the lesson (Engage). Both then provide students with hands-on investigations (Exploration). They each follow with sense-making activities (Explanation), connect students' ideas to a new, real-world context (Elaboration), and conclude

FIGURE 1.

Conceptual storyline probe.

<table>
<tr><th>Amy's Lesson</th><th>Steph's Lesson</th></tr>
<tr><td>The teacher challenges students to come up with examples from everyday life where matter changes from one form to another (e.g., solid to liquid). The class discusses factors involved in these changes.

Students, in groups, visit a variety of stations (with solids, liquids, and gases) for the purpose of determining whether all matter (a) has a definite shape; (b) takes up space/has volume; and (c) has mass. For example, students use a scale to compare the mass of a balloon that is inflated with one that is deflated.

Students are asked to generate a list of things that are/ are not "matter." Each group presents a chart to the class and discusses their reasoning.

Students make "ice cream in a bag," exploring factors that affect changes in state (liquid to solid) that the ingredients undergo. They experiment with the recipe to try to shorten the time required for the ice cream to be ready.

Students are provided cards depicting common objects and are asked to sort these based on whether they are solid, liquid, or gas—then to describe why they placed objects where they did. The class tries to reach consensus on how each object should be classified. Some interesting items provoke discussion—such as ice cream. It can be frozen solid but left out it melts. Similarly, chocolate sauce is liquid when heated but becomes solid when it cools.</td><td>The teacher challenges students to brainstorm examples from everyday life where matter changes from one form to another (e.g., solid to liquid). The class discusses factors they think are involved in these changes.

Students work in groups to complete a challenge—be the first team to melt the ice cube you've been provided (in a resealable bag). Students think about factors they brainstormed and how these relate to ice melting. They come up with a plan to test their ideas.

Groups share results of their investigation, and the teacher asks them to notice patterns. The class agrees that temperature and surface area are two factors that were important for ice melting. One group also notices that color played a role (they put theirs in the sun on top of black paper). The teacher indicates that black objects absorb more heat energy from the sun. She relates this to students' experiences with a black car parked in the sun versus a white car. She asks students to identify other sources of heat energy (from the light/sun/their bodies) that helped melt the ice.

The teacher next performs a demonstration and discusses how salt can be used to melt ice in driveways and sidewalks—but notes that this can damage lawns. She challenges groups to use what they know to come up with a way to melt ice on sidewalks and driveways without using salt. Students gather materials and test their plans.

Students create a brochure to distribute to the school and local community that explains how to melt ice on sidewalks and driveways without using salt. They describe their method and explain how it works using the concept of energy and changes to states of matter.</td></tr>
</table>

with an opportunity for students to communicate their new learning (Evaluation). Yet, there are key differences in how they address the topic of matter.

Amy begins her lesson by eliciting students' prior knowledge of how matter changes form, but this storyline is not continued further in later activities. While Amy's lesson aligns with the 5E learning cycle, her storyline lacks coherence, alternating from multiple topics, including changes in states of matter to distinguishing matter vs. nonmatter. In contrast, Steph's activities not only align with the purpose of each phase of the 5E learning cycle, but all contribute to a central storyline about changes in states of matter. As students work through each 5E activity, they gain an understanding of how matter changes state and the factors that contribute to this. This storyline also helps students connect to the crosscutting concept of energy.

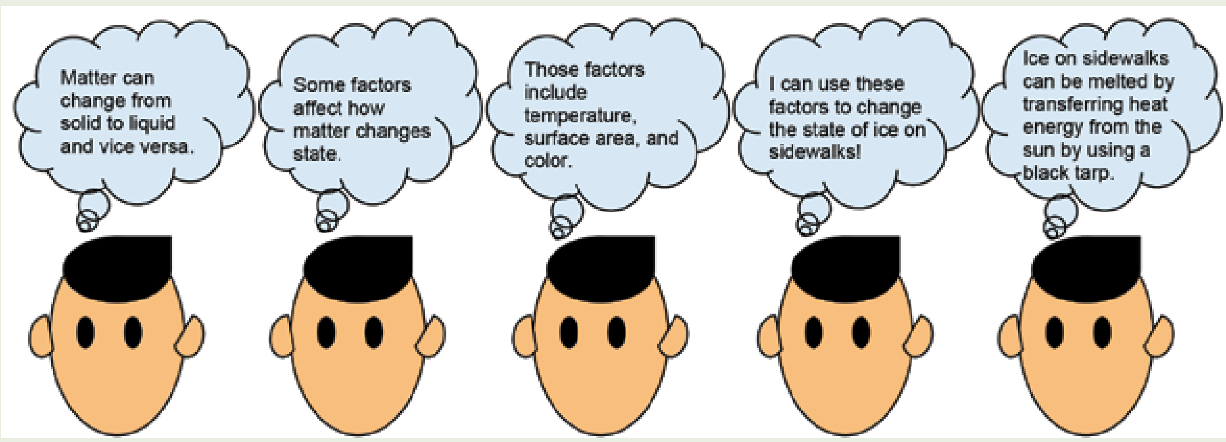
Without prompting, teachers may not pick up on differences in the conceptual storyline of the two lessons. However, teachers report it becomes difficult *not* to see this dimension of lesson design once they recognize it.

Linking Activities to Student Thinking

In addition to helping teachers recognize conceptual coherence, teachers also use conceptual storylines as a planning tool to develop or modify

FIGURE 2.

Student idea development across activities in a learning cycle.



ENGAGE activity: Brainstorming examples of changes in states of matter	**EXPLORATION activity:** Melting an ice cube challenge *Practice: Planning and carrying out investigations*	**EXPLANATION activity:** Discussion of factors that affect changes in states of matter. *Practice: Analyzing and interpreting data Engaging in argument from evidence*	**EXTENSION activity:** Engineering a way to melt ice on driveways or sidewalks. *Practice: Designing solutions*	**EVALUATION activity:** Communicating the solution to an audience. *Practice: Constructing explanations Communicating information*

lessons. Because teachers naturally describe their lessons in terms of activities, we begin with an exercise in which teachers describe what students should be thinking and understanding as they complete each of the activities. See Figure 2 for one group's interpretation of Steph's lesson.

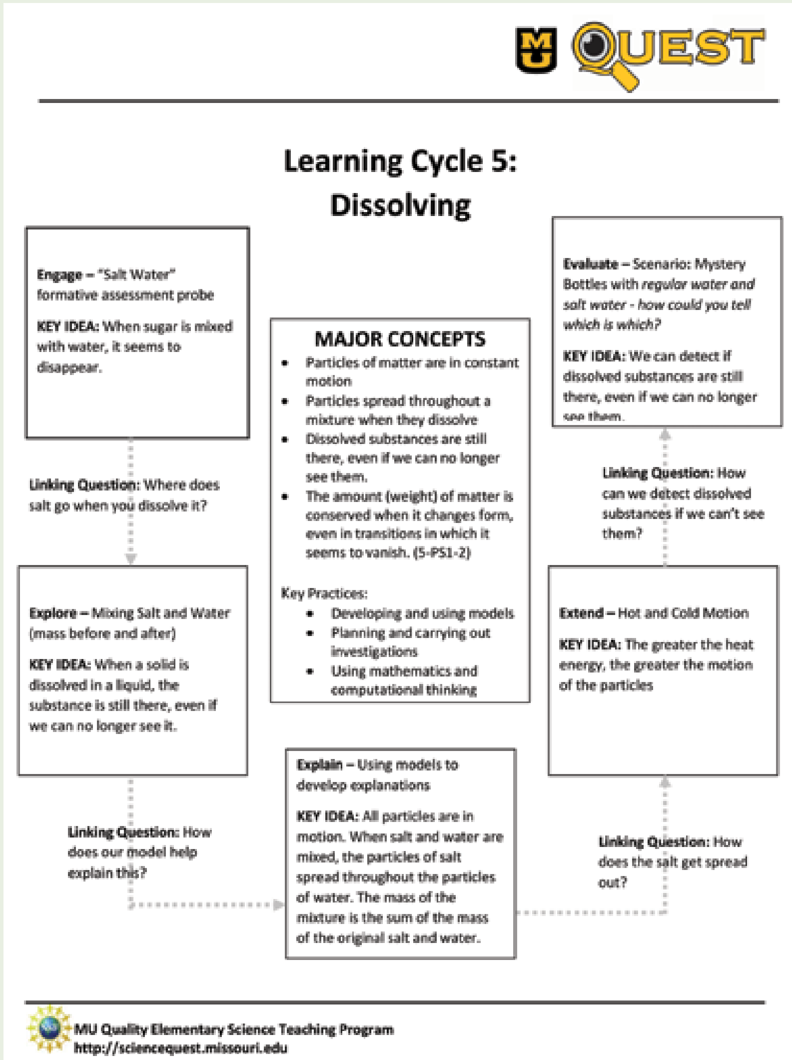
Building Storylines Around Disciplinary Core Ideas

Developing conceptual storylines is particularly important when considering that the intent of the *Next Generation Science Standards* is to increase coherence in K–12 science education (NGSS Lead States 2013). Teachers in this professional development program use a conceptual storyline map (Figure 3), based on Rodger Bybee's work (2015), to outline a lesson around particular disciplinary core ideas (DCIs). They then break the DCIs down into segments and identify key questions that help students follow the storyline of the lesson (see Figure 3). For example, the storyline for a lesson on dissolving would focus on the DCI stating that the amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish (5-PS1.A).

Because we use this tool to plan the science lessons we teach in our program, teachers can compare our conceptual storyline to the development of their own thinking, as students, during this experience. Using the conceptual storyline map to develop their own 5E lessons allows teachers to focus on key science ideas students will encounter during each phase of the lesson.

FIGURE 3.

Conceptual storyline map.



Building Conceptual Coherence

Building lessons with coherent conceptual storylines proves challenging for teachers, particularly when using new and unfamiliar content. In our experience, teachers need a strong understanding of science content to build conceptual storylines that promote deep learning.

Conceptual coherence offers a

means of connecting the 5E model to the *NGSS* through specific ideas during each phase of the learning cycle in order for students to develop understanding of a particular DCI. This is particularly important when achieving depth of understanding in a way that allows students to continually build on previous ideas and revise their knowledge and abilities (NGSS Lead States 2013).

Conclusion

We encourage teachers to begin looking at lessons they are provided, lessons they modify, or lessons they create and ask themselves, *What's the story? What are students doing in this lesson, and what ideas do they develop through those activities? How do the ideas link together, and what essential understandings does the storyline build toward?*

With well-structured and coherent storylines, students' spontaneous questions often relate to the next activity or idea we have planned for them to explore—just as you might have asked yourself after the season finale of *Stranger Things*, *Why did Will get sick in the bathroom? What was the growling noise? How was he affected by being in Upside Down?* ■

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